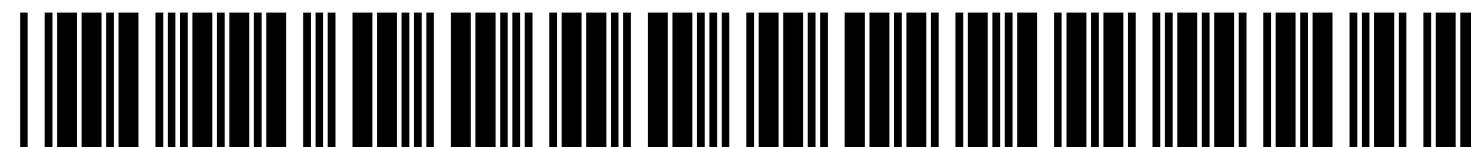
US007070891B2

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Jeong et al.

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(45) **Date of Patent: Jul. 4, 2006**

(54) **PHOTOMASK, METHOD FOR MANUFACTURING THE SAME, AND METHOD FOR MEASURING OPTICAL CHARACTERISTICS OF WAFER EXPOSURE SYSTEM USING THE PHOTOMASK DURING OPERATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 207 days.

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G03C 5/00 (2006.01)
G03F 9/00 (2006.01)

(52) **U.S. Cl.** **430/30**; 430/5; 430/22

(58) **Field of Classification Search** 430/5, 430/30, 22
See application file for complete search history.

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(74) *Attorney, Agent, or Firm*—Mills & Onello LLP

(57) **ABSTRACT**

Provided are a photomask, a method for manufacturing the photomask and a method for measuring optical characteristics of a wafer exposure system, the measuring method using the photomask during manufacture. The photomask includes a substrate and a measuring pattern including a light opaque region pattern formed on the substrate and a plurality of light transmitting region patterns that are formed in regions divided by the light opaque region pattern and provoke phase shifts to provide phase differences to light transmitted through light transmitting regions. Precise measurements of the degree of a focus and lens aberrations of an exposure system using the photomask are obtained.

17 Claims, 11 Drawing Sheets

FIG. 1

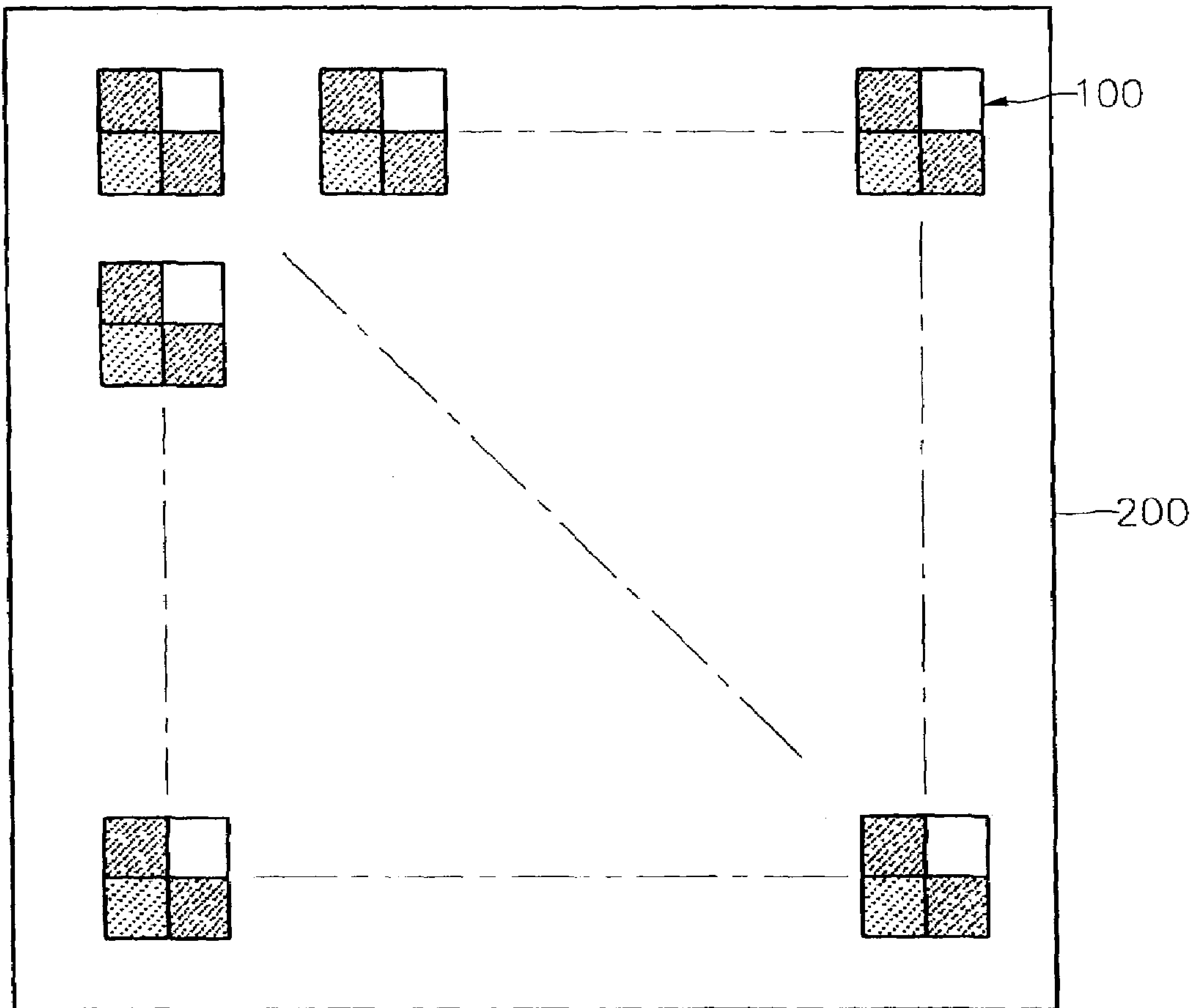


FIG. 2

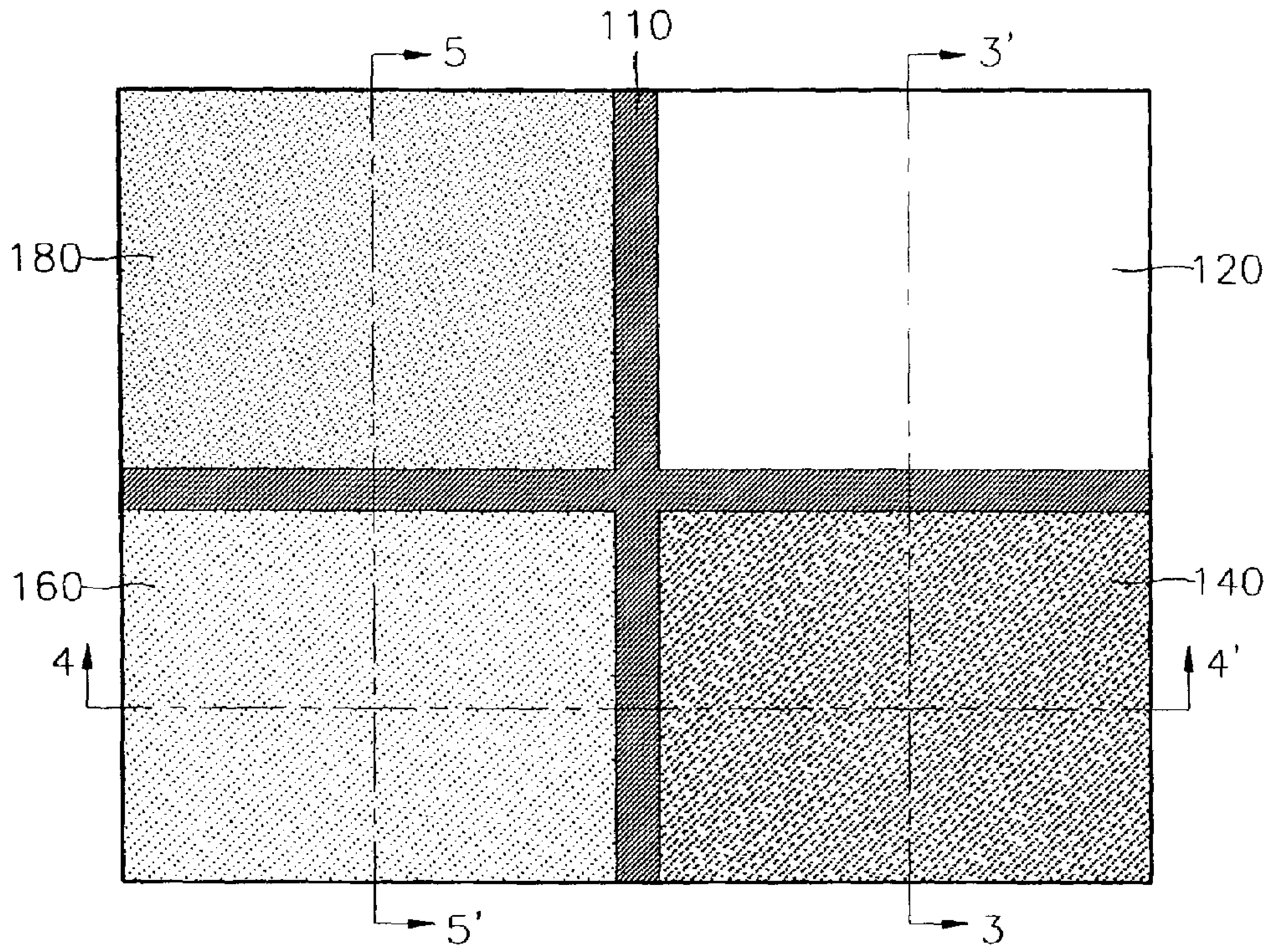


FIG. 3

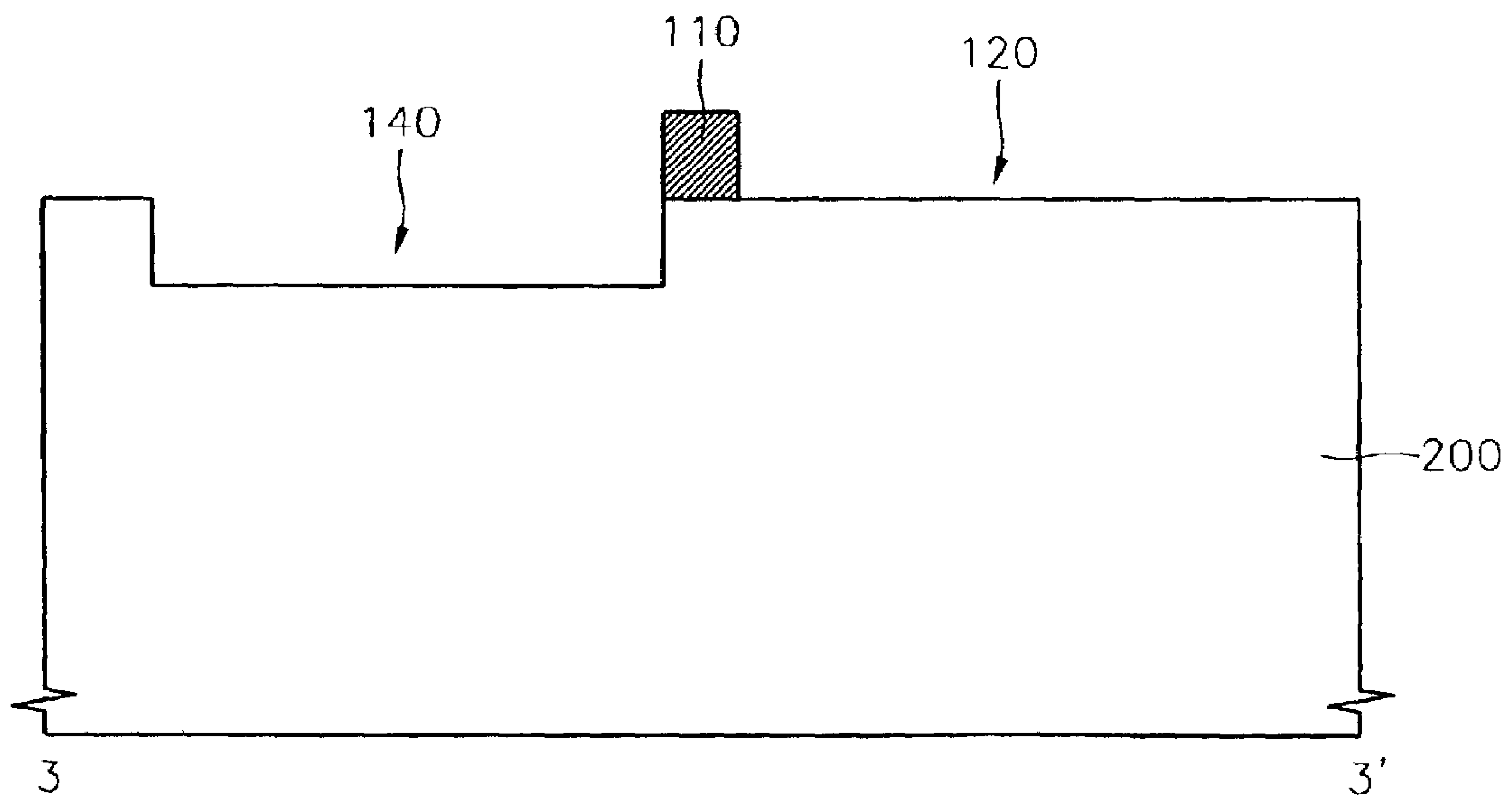


FIG. 4

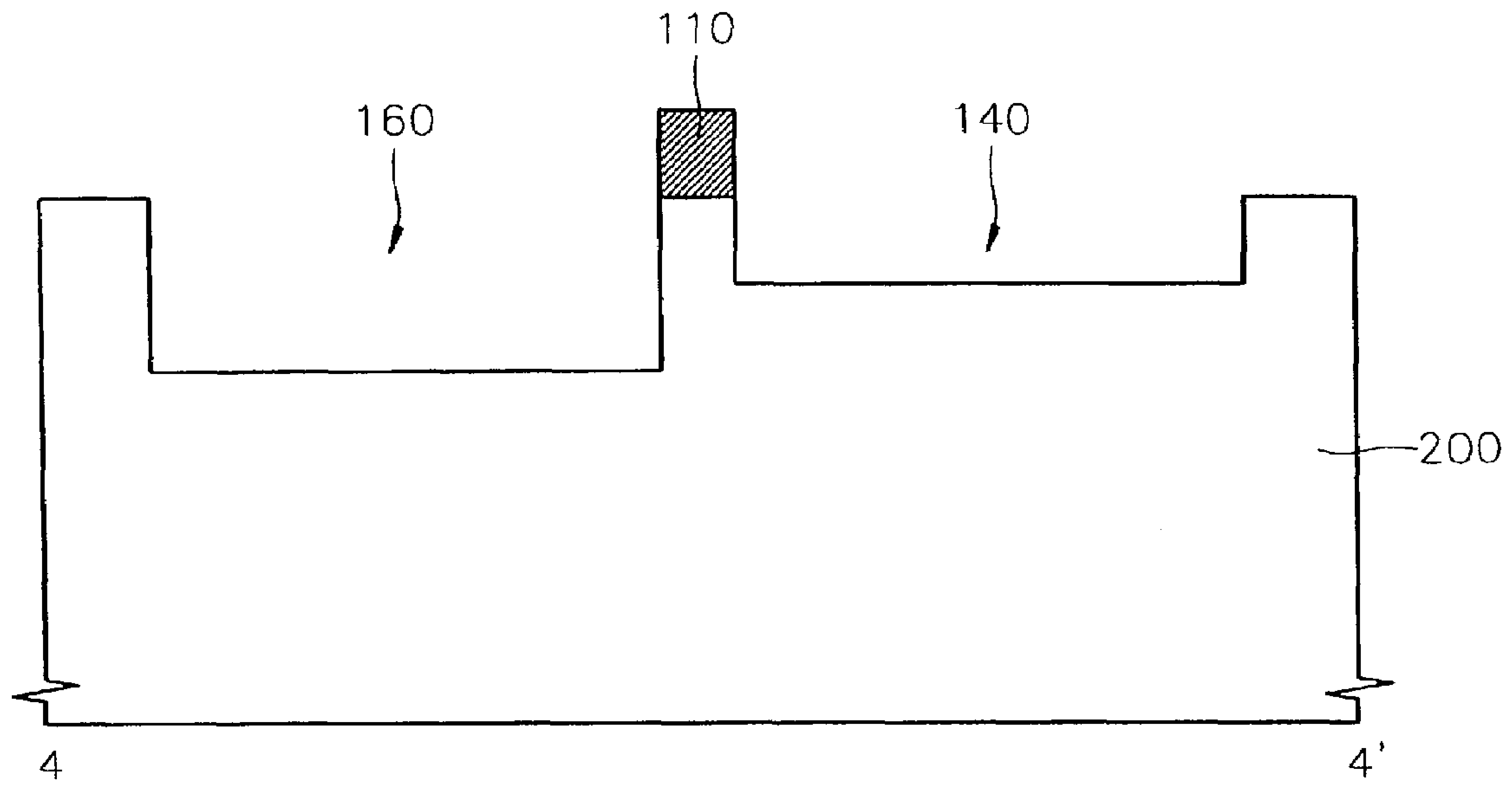


FIG. 5

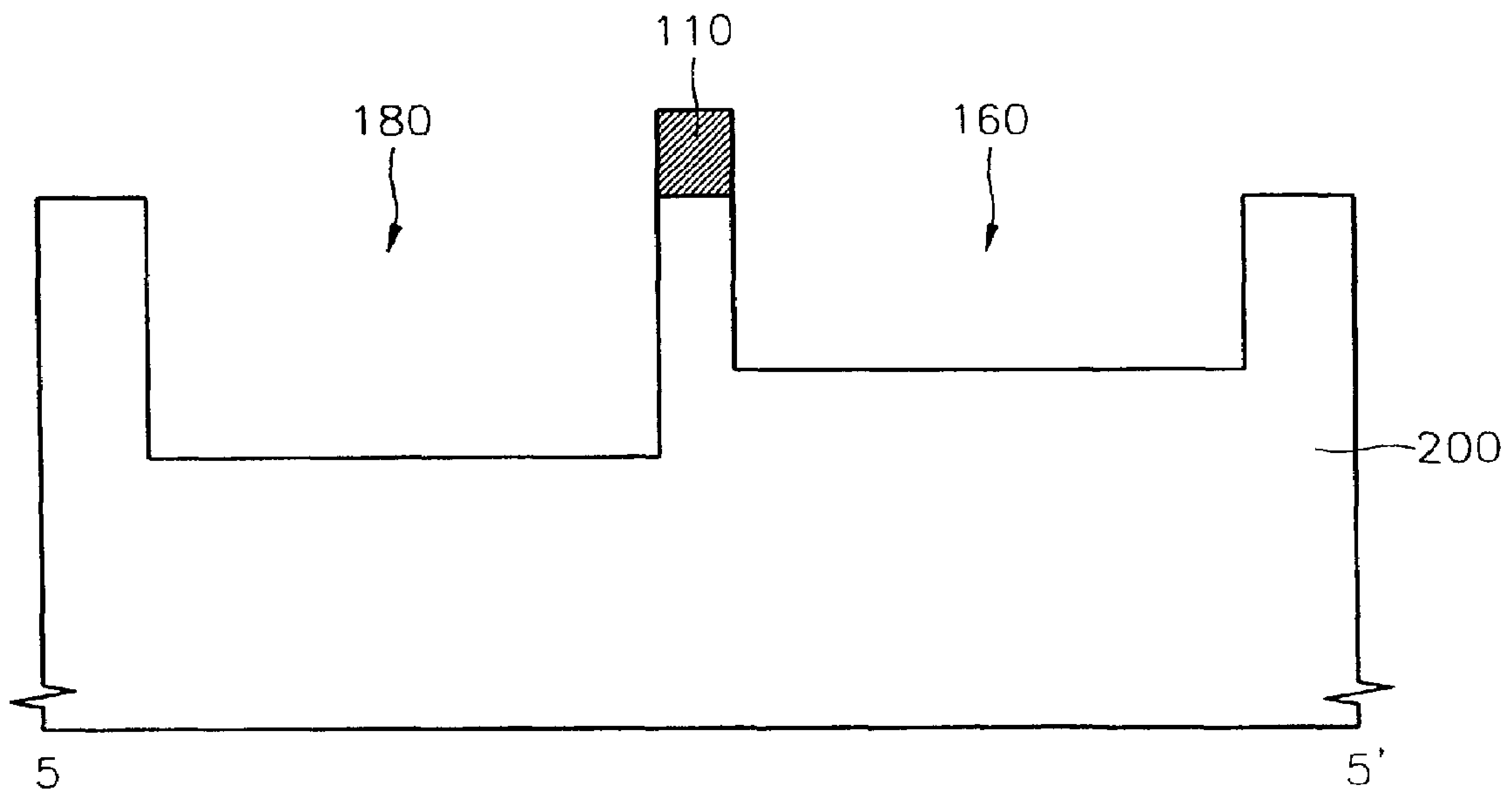


FIG. 6

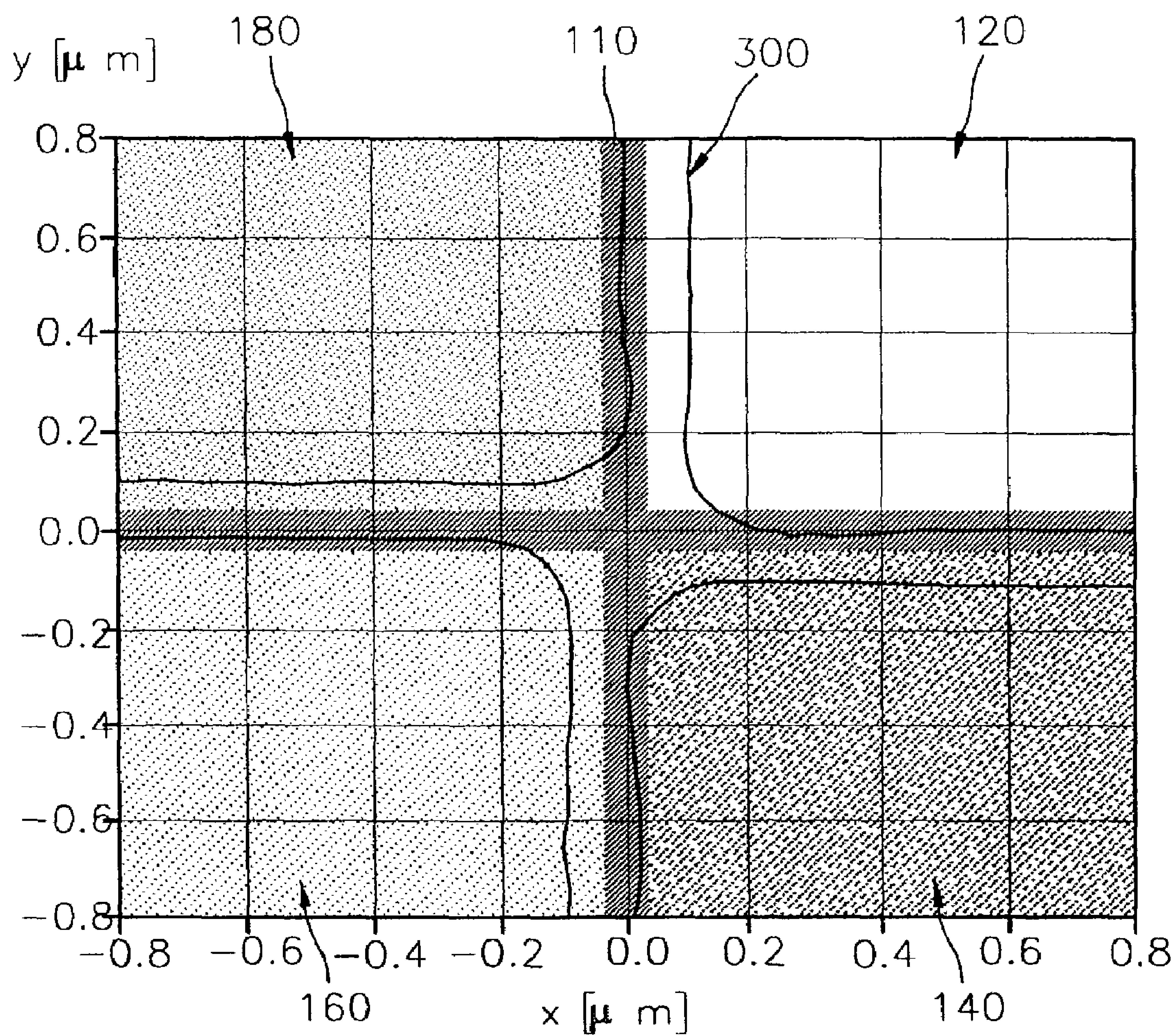


FIG. 7

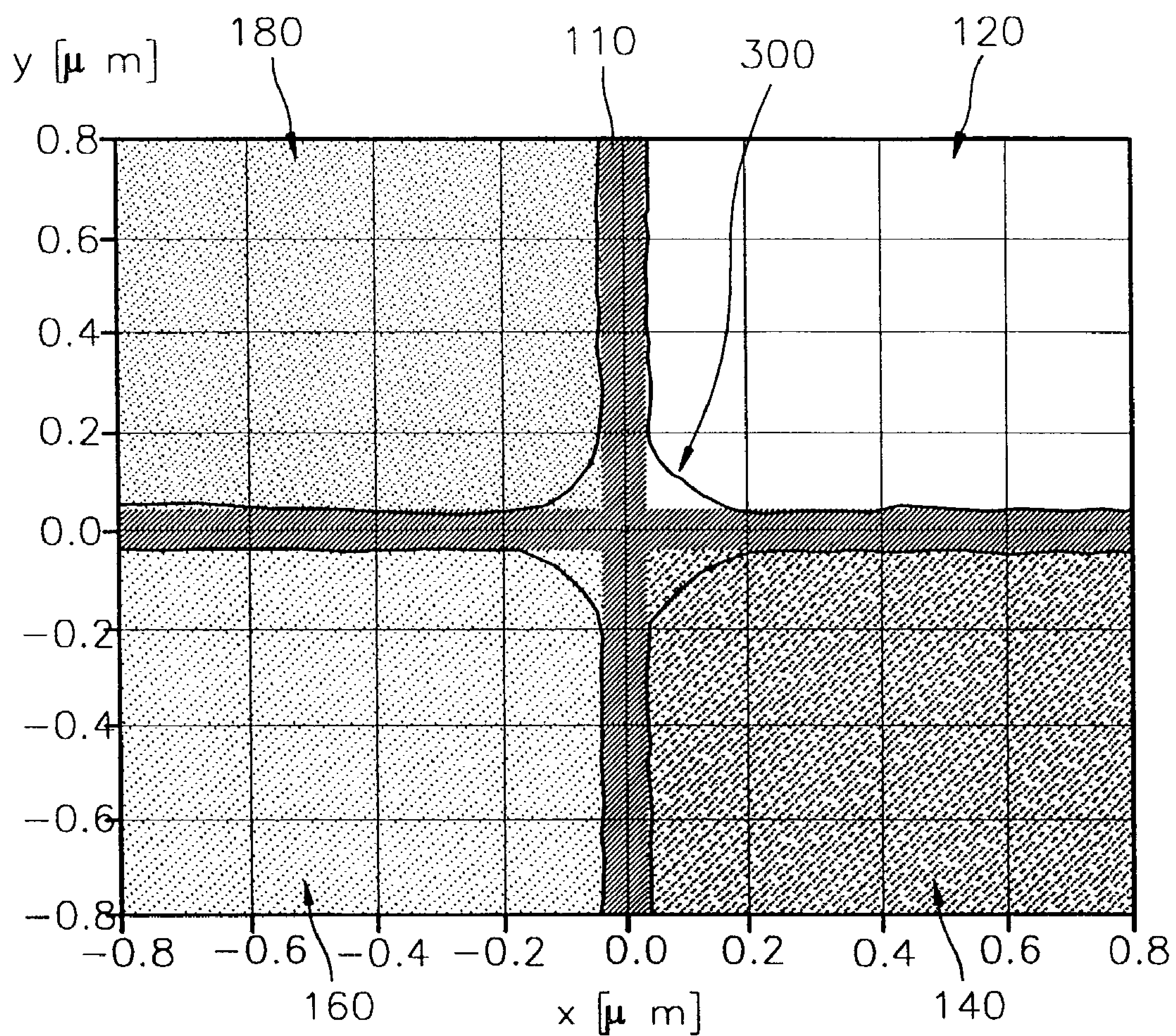


FIG. 8

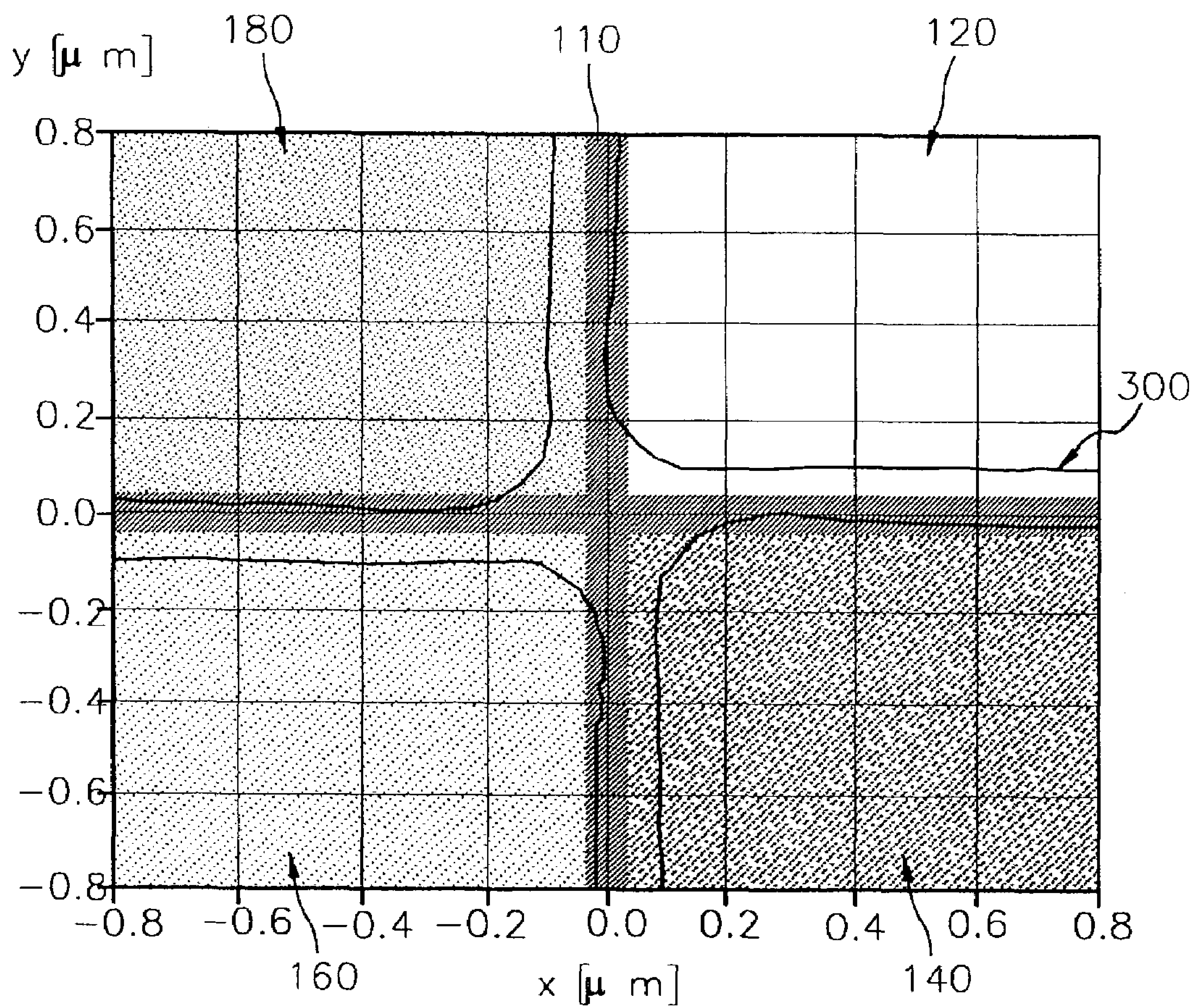


FIG. 9

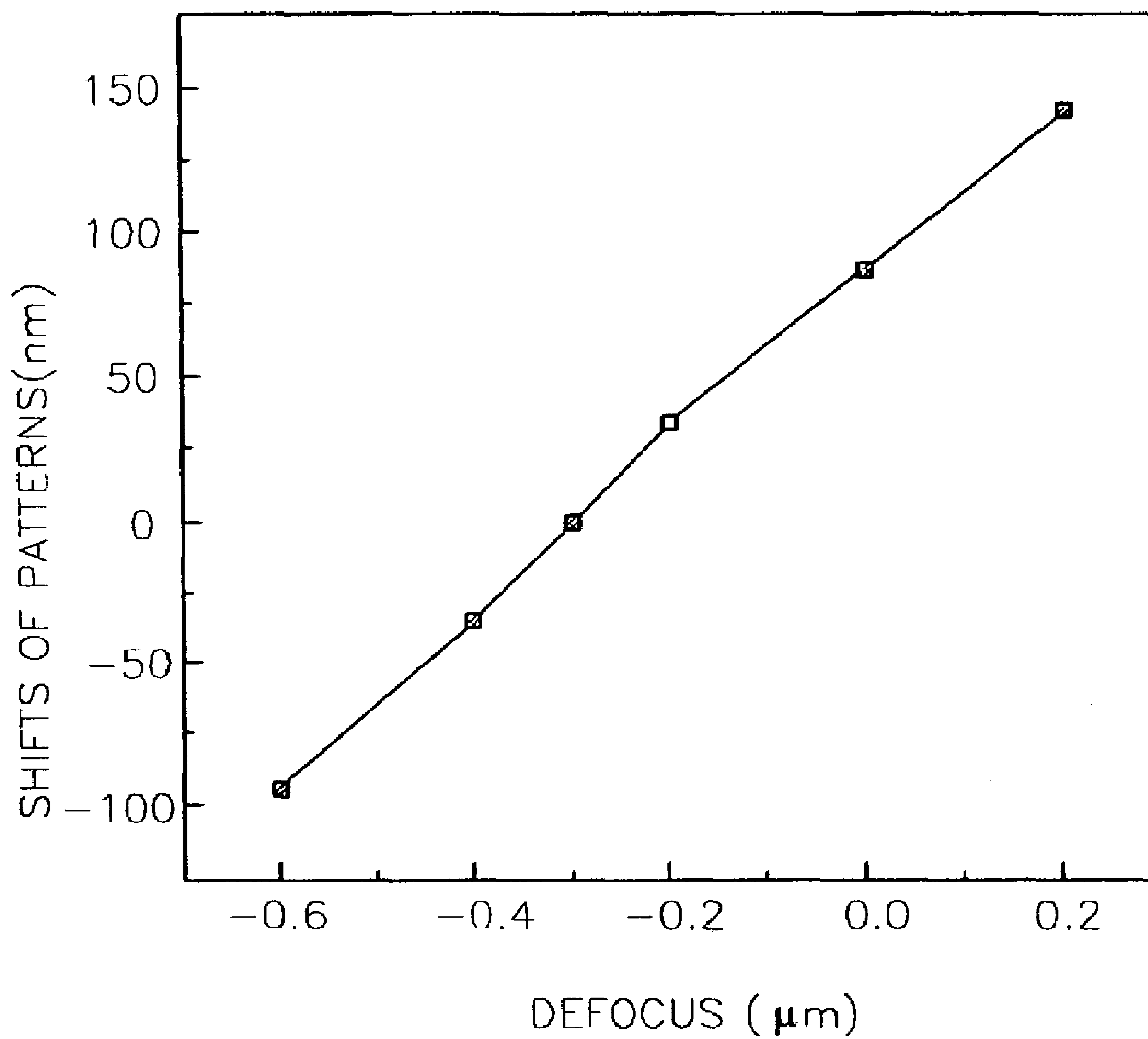


FIG. 10

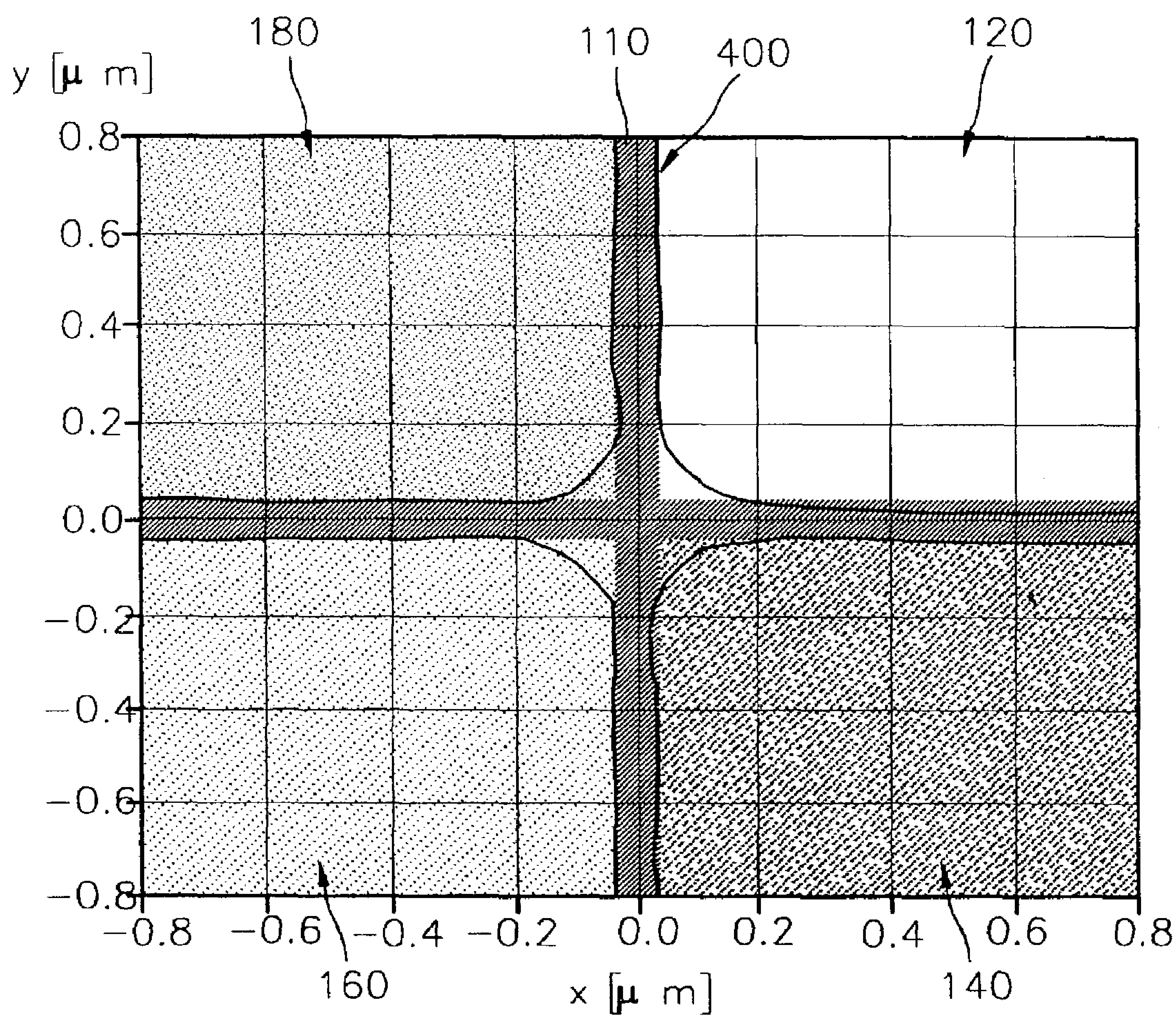


FIG. 11

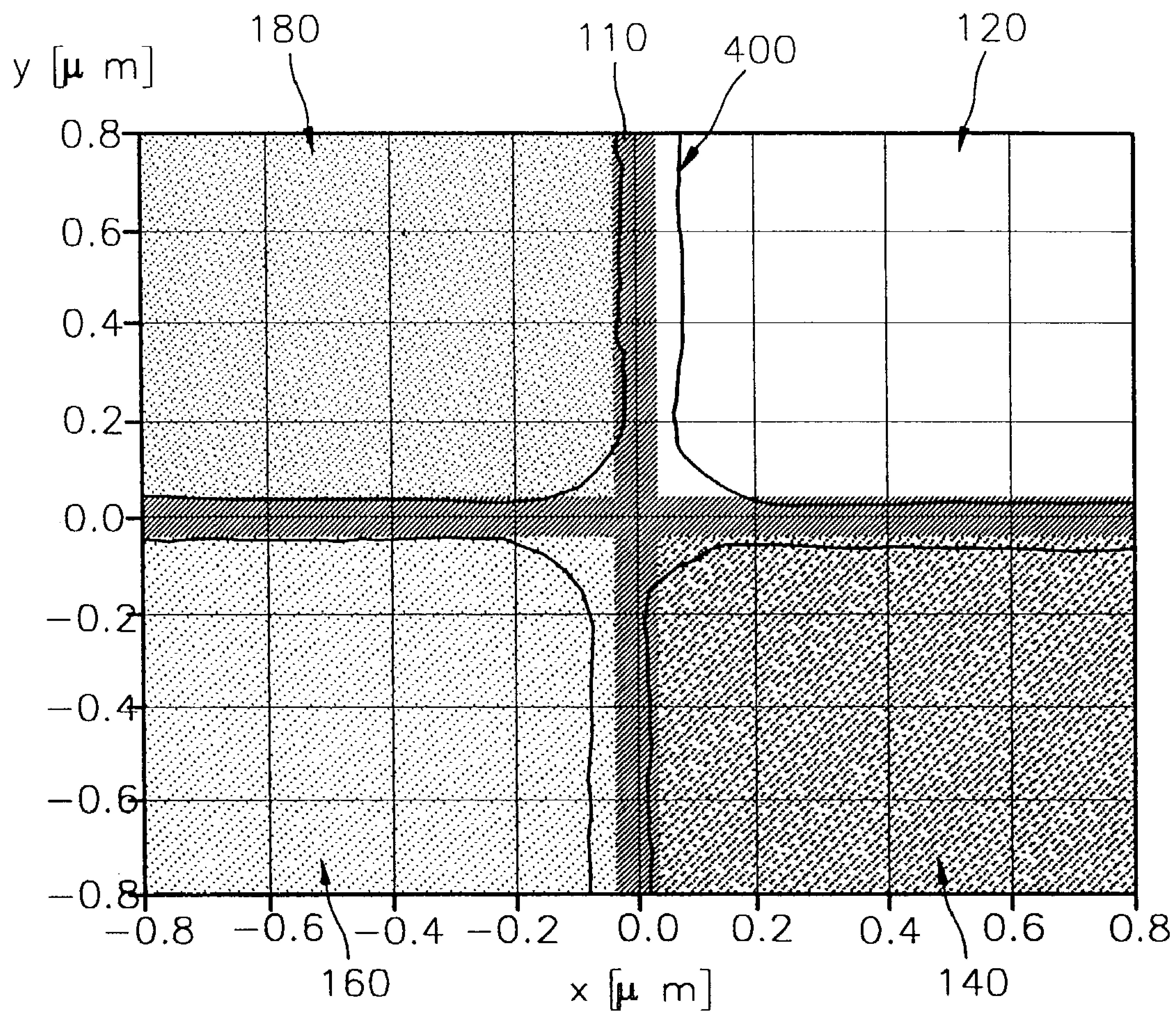


FIG. 12

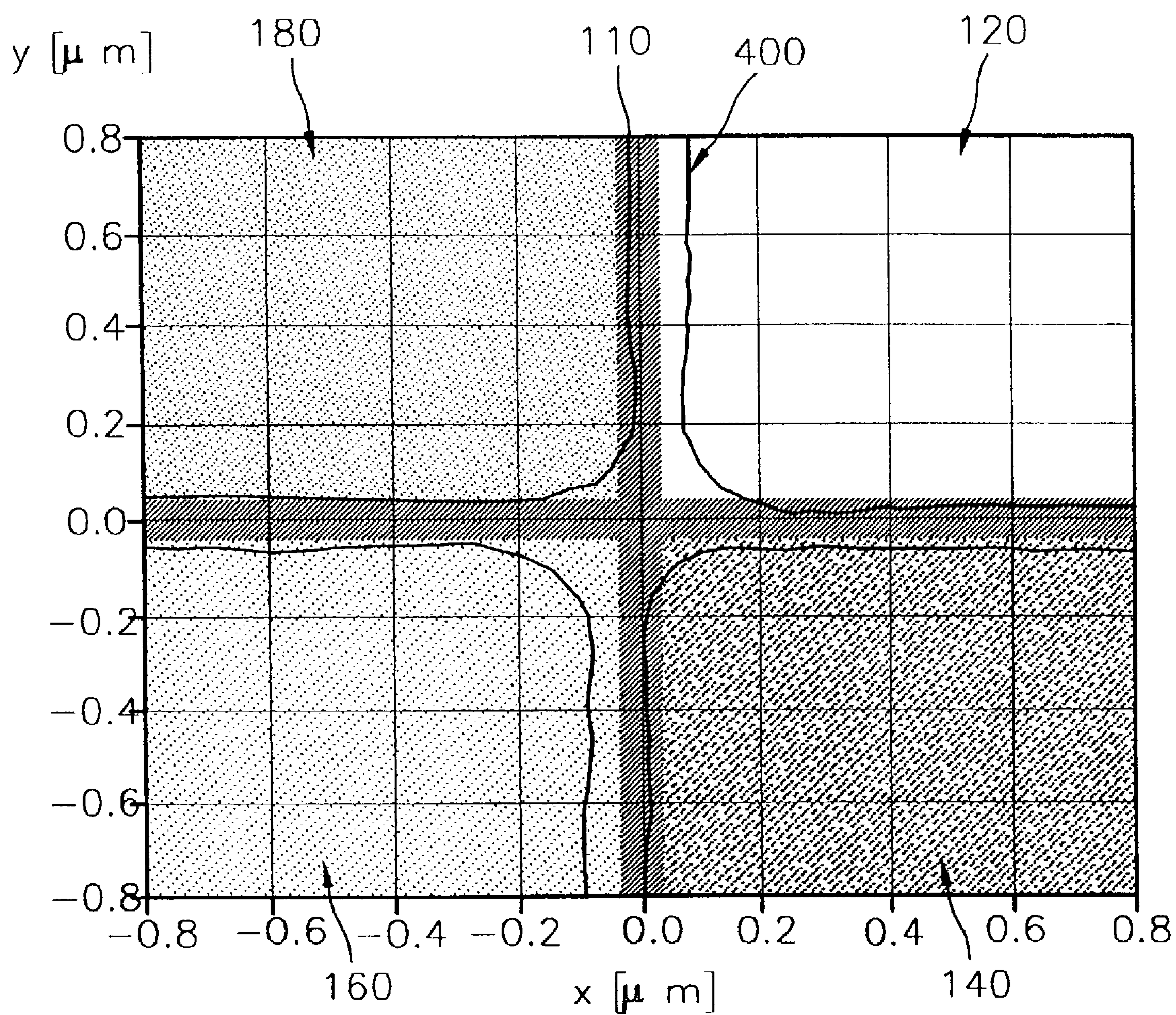
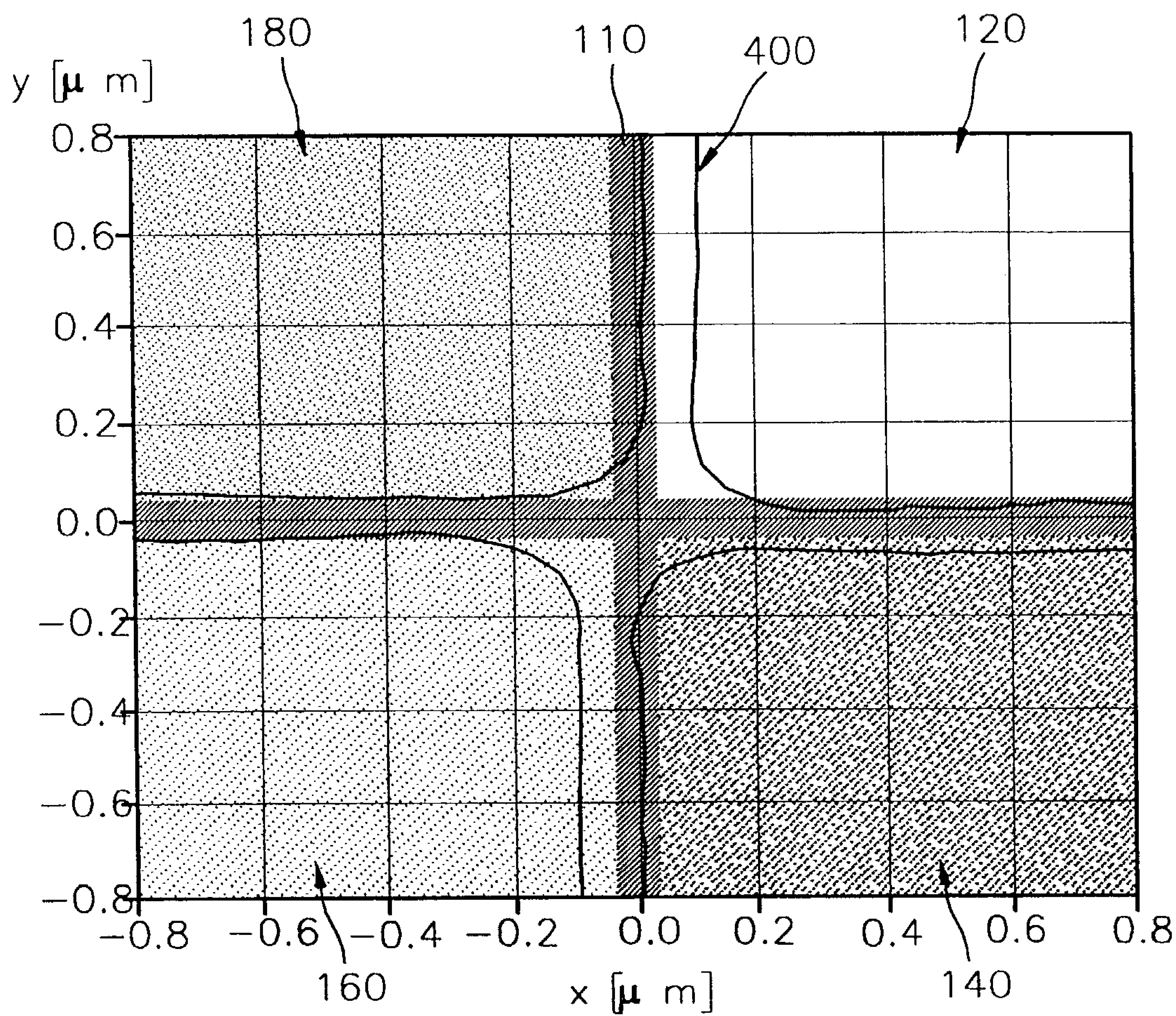


FIG. 13



PHOTOMASK, METHOD FOR MANUFACTURING THE SAME, AND METHOD FOR MEASURING OPTICAL CHARACTERISTICS OF WAFER EXPOSURE SYSTEM USING THE PHOTOMASK DURING OPERATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to manufacture of a semiconductor device, and more particularly, to a photomask used in a photolithography process for manufacturing a semiconductor device, a method for manufacturing the same and a method for measuring optical characteristics of a wafer exposure system, such as focus, lens aberration, etc., using the photomask during the operation.

2. Description of the Related Art

Recently, as a critical dimension (CD) in a device during manufacture of a semiconductor device becomes strict, patterns to be exposed are greatly influenced by distributions of lens focus and aberrations. Accordingly, understanding and controlling the distributions of the lens focus and aberrations during operation of the exposure system is recognized as being very important.

Until now, the methods for measuring or detecting a degree of focus of the exposure system have concentrated on measuring a CD of a real pattern on a real wafer according to the defocus of the exposure system using a scanning electron microscope, or measuring shifts of the patterns according to the defocus using overlay measuring equipment. However, it is known to be very difficult to precisely measure focus of the exposure system with the method for measuring a CD of a real pattern using a scanning electron microscope. That is, it is possible to measure a CD of a real pattern using a scanning electron microscope, but it is difficult to determine if the CD measured by this method represents the exact degree of a focus of the exposure system.

In addition, it is known that the method for measuring an overlay can measure a degree of focus of the exposure system relatively precisely, but presents difficulties in manufacturing a photomask for patterns observed with the overlay measurement equipment. Patterns for measuring an overlay are manufactured much larger than the patterns for the real devices. Accordingly, in the case of manufacturing a photomask corresponding to the patterns for measuring an overlay, a considerably large pattern should be manufactured on the photomask. It is known that the adhesiveness between a quartz blank and photoresist for a photomask is poor. Therefore, since a photoresist pattern should cover a large region on the quartz blank to manufacture a photomask including a large pattern, it occurs quite often that photoresist patterns are lifted when the photoresist patterns are exposed or developed.

Therefore, there is a need for a method for measuring or detecting optical characteristics such as focus or lens aberrations of the exposure system during manufacture of a semiconductor device, and a photomask used in the method.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a photomask used in measuring or detecting optical characteristics such as focus or lens aberrations of an exposure system more precisely during manufacture of a semiconductor device, and a method for manufacturing the same.

It is another object of the present invention to provide a method for measuring or detecting optical characteristics, such as focus or lens aberrations of the exposure system, more precisely during manufacture of a semiconductor device, using the photomask.

A photomask in accordance with the invention includes a substrate and a measuring pattern. The measuring pattern includes a light opaque region pattern formed on the substrate and a plurality of light transmitting region patterns that are formed in regions divided by the light opaque region pattern and provoke phase shifts to provide phase differences to light transmitted through light transmitting regions.

A plurality of the measuring patterns may be disposed on the substrate. The light opaque region patterns may be made of chrome layers. The phase difference may be 90°.

Alternatively, the photomask may include a substrate and a measuring pattern including a light opaque region pattern in a cross-shape formed on the substrate, and four light transmitting region patterns that are formed in four quadrants, respectively, divided by the light opaque region pattern and provoke phase shifts to provide phase differences to light transmitted through light transmitting regions.

Here, one of the light transmitting region patterns may be composed of a surface of one quadrant of the substrate and the other light transmitting region patterns are made of grooves with different depths on the other quadrants of the substrate.

In accordance with another aspect of the present invention, a method for manufacturing a photomask includes forming a light opaque region pattern on a substrate and forming a measuring pattern that comprises a light opaque region pattern and light transmitting region patterns, by forming a plurality of light transmitting region patterns that are formed in the regions divided by the light opaque region pattern and provoke phase shifts to provide the phase differences to the light transmitted through the regions.

Alternatively, the method for manufacturing a photomask includes forming a cross-shaped light opaque region pattern on the substrate and forming a measuring pattern that comprises four light transmitting region patterns formed in four quadrants divided by the light opaque region pattern and provoke phase shifts to provide phase differences to the light transmitted through the regions.

Forming the light transmitting region patterns can include setting one of the four quadrants as a light transmitting region pattern and sequentially etching portions of the other quadrants of the substrate to different thicknesses to sequentially form other light transmitting region patterns with grooves having different depths.

In accordance with another aspect of the present invention, there is provided a method for measuring focus of a wafer exposure system during a manufacture of a semiconductor device, using a photomask including a measuring pattern that includes a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate and provoke phase shifts to provide phase differences to light transmitting the region patterns. The method includes performing a photolithography process to transfer the patterns based on the measuring patterns on the wafer; measuring degrees of shifts of the transferred patterns on the wafer; and measuring focus of an exposure system within the degrees of the shifts of the transferred patterns.

Preferably, the light opaque region pattern formed in a cross shape, dividing the four quadrants of the light transmitting region patterns, and the degrees of shifts of the transferred pattern are measured from a degree of relative shift of a certain transferred pattern to the other light

transmitting region patterns of the quadrant regions. Preferably, one of the light transmitting region patterns is made of one of the four quadrants of the substrate, and the other light transmitting region patterns are made of grooves with different depths on the other quadrants of the substrate. Preferably, the degree of shift of the transferred patterns is measured from the transferred patterns, based on the light transmitting region patterns of the quadrant regions in the up/down, left/right or one of the directions during manufacture.

Preferably, the method includes disposing a plurality of the measuring patterns on the substrate of the photomask, measuring the degrees of the shifts of the transferred patterns based on the disposed measuring patterns, and obtaining a focus map for all regions on the wafer corresponding to the photomask.

Preferably, the method further includes transferring the patterns with variation of focus of the exposure system and measuring several times the degree of shifts of the transferred patterns and obtaining an optimum focus of the exposure system.

Preferably, measuring the degree of shifts of the transferred patterns is performed by observing the transferred patterns with a scanning electron microscope.

In accordance with another aspect of the present invention, there is provided a method for measuring aberration of a wafer exposure system, during a manufacture of a semiconductor device. The method uses a photomask including measuring patterns that include a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate and provoke phase shifts to provide phase differences to lights transmitted through the region patterns. The method includes performing a photolithography process on a wafer to transfer the patterns based on the measuring patterns on the wafer; measuring a degree of shift of the transferred patterns on the wafer; and measuring a focus of an exposure system from the degree of the shift of the transferred patterns.

Preferably, the light opaque region is formed in a cross shape dividing the four quadrants of the patterns for light transmitting regions and the degree of shift of the transferred patterns are measured from the degree of shift of the transferred patterns based on the light transmitting region patterns of the quadrant regions. Preferably, one of the light transmitting region patterns is made of one of the four quadrants of the substrate, and the other light transmitting region patterns are made of grooves with different depths on the other quadrants of the substrate. Preferably, the degree of shift of the transferred patterns is measured from the transferred patterns, based on the light transmitting region patterns of the quadrant regions in the up/down, left/right or one of the directions during manufacture.

Preferably, the method further includes disposing a plurality of measuring patterns on the substrate of the photomask, measuring the degree of the shift of the transferred patterns based on the disposed measuring patterns and obtaining an aberration map for all regions on the wafer corresponding to the photomask.

Preferably, the method further includes transferring the patterns with variation of aberration of the exposure system and measuring several times the degree of shifts of the transferred patterns and obtaining an optimum aberration of the exposure system. Here, the aberration may be an astigmatism aberration.

Preferably, measuring the degree of shifts of the transferred pattern is performed by observing the transferred pattern with a scanning electron microscope.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a schematic view of a photomask according to an embodiment of the present invention.

FIG. **2** is a plane view of a unit pattern adapted in a photomask according to the embodiment of the present invention.

FIG. **3** is a cross-sectional view along the cutting plane line **3–3'** in FIG. **2** to show a unit pattern adapted in a photomask according to the embodiment of the present invention.

FIG. **4** is a cross-sectional view along the cutting plane line **4–4'** in FIG. **2** to show a unit pattern adapted in a photomask according to the embodiment of the present invention.

FIG. **5** is a cross-sectional view along the cutting plane line **5–5'** in FIG. **2** to show a unit pattern adapted in a photomask according to the embodiment of the present invention.

FIGS. **6** through **8** are schematic views showing the shifts of the unit pattern adapted in the photomask, according to the defocus variation to show a method for measuring the focus of the wafer exposure system of the embodiment of the present invention.

FIG. **9** is a schematic graph showing degrees of the shifts of the pattern according to the defocus variation;.

FIGS. **10** through **13** are schematic views showing the shifts of the unit pattern adapted in a photomask according to the variations of lens aberrations of the wafer exposure system to show a method for measuring the degree of lens aberrations of the wafer exposure system according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. In the drawings, the thickness of layers and regions are exaggerated for clarity. It will also be understood that when a layer is referred to as being "on" another layer or a substrate, it can be directly on the other layer or the substrate, or intervening layers may also be present.

The method for measuring optical characteristics of an exposure system, such as focus and lens aberration, adapts a phase shift-type photomask, and measures the focus and the lens aberration by measuring the shifts of the patterns transferred on the wafer by the phase shift-type photomask with a scanning electron microscope. More precisely, an embodiment of the present invention provides a photomask that includes patterns for measuring shifts of the patterns transferred by the exposure system.

Referring to FIG. **1**, a first embodiment of the present invention includes a plurality of measuring unit patterns **100**. It is possible to dispose the plurality of measuring unit patterns **100** within a region of the photomask. The measuring unit patterns **100** are formed on a photomask substrate **200** by photo exposures and selective etch.

FIG. **2** is a plane view of a unit pattern adapted in a photomask according to an embodiment of the present invention. FIG. **3** is a cross-sectional view along the cutting plane line **3**–**3'** in FIG. **2** to show a unit pattern adapted in a photomask according to an embodiment of the present invention. FIG. **4** is a cross-sectional view along the cutting plane line **4**–**4'** in FIG. **2** to show a unit pattern adapted in a photomask according to an embodiment of the present invention. FIG. **5** is a cross-sectional view along the cutting plane line **5**–**5'** in FIG. **2** to show a unit pattern adapted in a photomask according to an embodiment of the present invention.

Referring to FIG. **2**, the measuring unit pattern **100** includes a light opaque region pattern **110** and light transmitting region patterns **120**, **140**, **160**, and **180**, divided by the light opaque region pattern **110**.

In one embodiment, the light opaque region pattern **110** is made of a chrome pattern that is deposited and patterned on a photomask substrate **200**, for example, a transparent quartz substrate as shown in FIGS. **3** through **5**. The light opaque region pattern **110** is formed in a cross-shape to be used as a boundary dividing a plurality of light transmitting region patterns **120**, **140**, **160**, and **180** consisting of four divided region patterns.

The light transmitting region patterns **120**, **140**, **160**, and **180**, divided by the light opaque region pattern **110**, are each designed for transmitting light to have different phases. That is, the four light transmitting region patterns **120**, **140**, **160**, and **180** are classified clockwise as the first, second, third and fourth quadrant, respectively. A transmitting light phase shifts by 0° in the first light transmitting region pattern **120** of the first quadrant, 90° in the second light transmitting region pattern **140** of the second quadrant, 180° in the third light transmitting region pattern **160** of the third quadrant, and 270° in the fourth light transmitting region pattern **180** of the fourth quadrant. It is preferable that each light transmitting region pattern **120**, **140**, **160**, and **180** have a phase difference of 90° to each previous pattern.

The light transmitting region patterns **120**, **140**, **160**, and **180**, are prepared as phase shift regions to give phase differences to the light transmitted by each region. For example, as shown in FIGS. **2** through **5**, the light transmitting region patterns **120**, **140**, **160**, and **180** are formed on the substrate, by forming the light opaque region pattern **110** into a chrome pattern with the photolithography process and then opening the regions and etching them sequentially. At this time, the first light transmitting region pattern **120** is formed naturally by not etching the first quadrant.

It is preferable that an etching thickness of the substrate **100** in the second quadrant be set so that the light transmitted through the second light transmitting region pattern **140** has a phase difference of 90° from the light transmitted through the first light transmitting region pattern **120** of the first quadrant.

Next, as shown in FIG. **4**, after opening the third quadrant and etching the substrate **200** into the third quadrant of a different thickness from the etching thickness in the second quadrant and then the third light transmitting region pattern **160** is formed. At this time, it is preferable that an etching thickness of the substrate **100** in the third quadrant be set so that the light transmitted through the third light transmitting region pattern **160** have a phase difference of 90° from the light transmitted through the second light transmitting region pattern **140** of the second quadrant. In addition, an etching thickness of the substrate **100** in the third quadrant is set so that the light transmitted through the third light transmitting region pattern **160** has a phase difference of 180° from the light transmitted through the first light transmitting region pattern **120** of the first quadrant.

Next, as shown in FIG. **5**, after opening the fourth quadrant, etching the substrate **200** into the fourth quadrant of a different thickness from the etching thickness in the third quadrant and then the fourth light transmitting region pattern **180** is formed. At this time, it is preferable that an etching thickness of the substrate **100** in the fourth quadrant is set so that the light transmitted through the fourth light transmitting region pattern **180** has a phase difference of 90° from the light transmitted through the third light transmitting region pattern **160** of the third quadrant. In addition, an etching thickness of the substrate **100** in the fourth quadrant is set so that the light transmitted through the fourth light transmitting region pattern **180** has a phase difference of 270° from the light transmitted through the first light transmitting region pattern **120** of the first quadrant.

The measuring unit pattern **100** is designed to observe more precisely the shifts of the patterns on the wafer more precisely by optical characteristics, such as a degree of focus or lens aberration, by inducing phase differences to the lights transmitted through the light transmitting region patterns **120**, **140**, **160**, and **180**, respectively. FIG. **2** shows an example of forming the light opaque region pattern **110** in a cross-shape to divide the four quadrants, and the light opaque region pattern **110** is shifted to separate multiple quadrants, i.e., quadruple quadrants, if required. That is, the light opaque region pattern **110** is shifted to divide eight quadrants.

The measuring unit pattern **100** is disposed so that a plurality of photomasks are distributed as shown in FIG. **1**. It is possible to measure a single measuring unit pattern **110** in case of simply measuring a degree of focus of the exposure system. However, in the case of obtaining an entire degree of a focus by obtaining a focus map throughout the entire regions of the wafer, or obtaining an entire degree of aberrations by obtaining an aberration map throughout the entire region exposed on the wafer, it is possible to dispose a plurality of measuring unit patterns **100** on the entire regions of the photomask. At this time, it is possible to obtain both the degree of focus or lens aberration of the exposure system in each regions corresponding to the measuring unit patterns **100**. By collecting the above degrees of the focus or lens aberrations, it is possible to obtain a focus map and an aberration map. It is possible to obtain the optimum optical characteristics, such as the degree of focus or lens aberration by obtaining the focus map or the aberration map and to feed back them in the wafer exposure process.

As described above, a method for measuring the optical characteristics, such as the degree of focus or lens aberration, is illustrated by using a photomask including the measuring unit pattern **100**.

At first, exposures and developments are performed on the photoresist layer on the wafer according to changes of the focus of the photo exposure equipment by using the photomask as shown in the embodiments of the present invention. At this time, what is really observed with a scanning electron microscope is a developed wafer, namely, a developed photoresist layer. What is to be observed with the scanning electron microscope is a pattern formed by transferring the measuring unit pattern **100**. The patterns formed on the wafer by corresponding to the measuring unit pattern **100** observed by the scanning electron microscope are as shown in FIGS. **6** through **8**.

FIG. **6** shows a pattern observed in the case that defocus is set as 0.0 um, FIG. **7** shows a pattern observed in the case

that defocus is set as −0.3 um and FIG. **8** shows a pattern observed in the case that a defocus is set as −0.6 um. The numeral "**300**" in FIGS. **6** through **8** denotes outlines of the real patterns observed in the real patterns **300**. The real patterns **300** observed on the wafer show shifts in the patterns according to the focus set in the exposure system.

The real pattern **300** in FIG. **6** is a pattern transferred by the light opaque region pattern (**110** in FIG. **2**) and the light transmitting region patterns (**120**, **140**, **160** and **180** in FIG. **2**). At this time, since the light transmitting region patterns **120**,**140**, **160**, and **180** give a phase difference to the transmitting lights, the patterns **300** on which the light transmitting region patterns **120**,**140**,**160**, and **180** are transferred are shifted according to the degrees of the focus of the exposure system.

As shown in FIGS. **6** through **8**, it is possible to number the shifts of the real pattern **300** of the exposure system by focus by measuring the degrees of shifts of the real pattern **300**. It is possible to find an optimum focus where a minimum pattern shift occurs. At this time, degrees of the shifts of the pattern **300** are measured by the degree of shift of a vertical/horizontal line of the outlines of the patterns in the up/down or the left/right directions.

Considering only the patterns **300** corresponding to the first light transmitting region pattern **120** as shown in FIGS. **6** through **8**, the moves of the patterns **300** are minimized in FIG. **7**, comparing to FIGS. **6** and **7**. In addition, the pattern **300** in FIG. **6** moves in the right direction, comparing to FIG. **7** and the pattern in FIG. **8** moves in the left direction, comparing to FIG. **7**.

Comparing the shifts of the patterns according to the defocus of the exposure system, an optimum focus, where a minimum pattern shift occurs, can be obtained. That is, the defocus value in FIG. **7** is considered as the optimum focus value of the exposure equipment.

FIG. **9** is a graph showing movements of the patterns according to the defocus of the exposure system. According to FIG. **9**, an optimum focus value of −0.3 um is obtained.

Referring to FIGS. **6** through **9**, the method for searching for the optimum focus value of the exposure system is described, considering the movements of the patterns according to the defocus for a measuring unit pattern **100**. In addition, if the above measure is performed at each position of a multiple measuring unit patterns **100**, a focus map of the exposure system at each position of the measuring unit patterns **100** is also obtained. Thus, the optimum focus value throughout the entire exposure regions is obtained by the focus map.

Using this photomask including the measuring unit pattern **100**, it is possible to observe an aberration, specifically, an astigmatism aberration from the degree of shifts of the patterns formed on the wafer. Even though the focus of the exposure system is set as the optimum focus value, a pattern is sometimes shifted into a certain direction. This phenomenon depends on the astigmatism aberration. In a case where the exposure system has an astigmatism aberration, even if the exposure system has optimum focus in one direction, for example, a horizontal direction, and thus has no pattern shift in the direction, a pattern shift may occur in another direction, for example, in a vertical direction because the exposure system dose not have optimum focus in the vertical direction. A degree of shift of the pattern depends on the astigmatism aberration of the exposure system.

The astigmatism aberration of the exposure system can be measured using a photomask including the measuring unit pattern **100** in an embodiment of the present invention. At first, an exposure and a development are performed on the photoresist layer on the wafer according to changes of the focus of the photo exposure equipment, by using the photomask as shown in the embodiments of the present invention. At this time, what is really observed with a scanning electron microscope is a developed wafer, namely, a developed photoresist layer. What is to be observed with the scanning electron microscope is a pattern formed by transferring the measuring unit pattern **100**. The patterns formed on the wafer by corresponding to the measuring unit patterns **100** observed by the scanning electron microscope are shown in FIGS. **10** through **13**.

FIG. **10** is a pattern observed when the exposure system has an astigmatism aberration of 0.05 λ, FIG. **11** is a pattern observed when the exposure system has an astigmatism aberration of 0.1 λ, FIG. **12** is a pattern observed when the exposure system has an astigmatism aberration of 0.15 λ and FIG. **13** is a pattern observed when the exposure system has an astigmatism aberration of 0.2 λ. The lines denoted as the numeral "**400**" in FIGS. **10** through **13** are outlines of the real patterns observed on the real wafer. The real pattern **400** observed on the wafer shows changes of the pattern according to the astigmatism aberration in the exposure system in FIGS. **10** through **13**.

In FIG. **10**, the pattern **400** is a pattern transferred by the light opaque region pattern **110** in FIG. **2** and the light transmitting region patterns **120**, **140**, **160**, and **180** in FIG. **2** of the measuring unit pattern **100**. At this time, since the light transmitting region patterns **120**, **140**, **160**, and **180** have a function to give phase differences to the transmitting lights, the pattern **400** transferred by the light transmitting region patterns **120**, **140**, **160**, and **180** are remarkably shifted according to the astigmatism aberration of the exposure system.

As shown in FIGS. **10** through **13**, the pattern **400** is rarely shifted in the vertical direction. Accordingly, the exposure system has an optimum focus in the vertical direction. However, as shown in FIGS. **10** through **13**, the pattern **400** is shifted in the horizontal direction according to the degree of the astigmatism aberration. Therefore, an optimum astigmatism aberration, where a minimum shift occurs, is obtained by numerically expressing or comparing the shifts of the patterns according to the variation of the astigmatism aberration of the exposure system.

Referring to FIGS. **10** through **13**, the method for searching for the optimum astigmatism aberration value of the exposure system is described considering the movements of the patterns according to the variation of the astigmatism aberration for each unit pattern **100**. In addition, if the above mentioned measurement is performed at each position of a multiple measuring unit patterns **100**, an astigmatism aberration map of the exposure system at each position of the measuring unit patterns **100** is also obtained. Thus, the optimum astigmatism aberration value throughout the entire exposure regions is obtained by the astigmatism aberration map.

As described above, using this photomask including the measuring unit pattern **100**, it is possible to observe focus values and aberration values, specifically, astigmatism aberration values from the degrees of shifts of the patterns formed on the wafer. Therefore, it is possible to control the optimum focus and aberration of the exposure system using the measured focus or aberration values and analyze the focus or the aberration of the exposure system during manufacture of a semiconductor device. Thus, this could result in quality improvement of the semiconductor device.

It is noted that the present invention is not limited to the preferred embodiments described above, and it is apparent that variations and modifications can be made by those skilled in the art.

What is claimed is:

1. A method for measuring focus of a wafer exposure system during manufacture of a semiconductor device, comprising:

providing a photomask including a measuring pattern that includes a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring degrees of shifts of the transferred patterns on the wafer; and

measuring a focus of an exposure system within the degrees of the shifts of the transferred patterns.

2. The method of claim **1**, wherein the phase difference is 90°.

3. The method of claim **1**, the method further comprising:

transferring the patterns with variation of focus of the exposure system and measuring several times the degree of shifts of the transferred patterns; and

obtaining an optimum focus of the exposure system.

4. The method of claim **1**, wherein measuring the degree of shifts of the transferred patterns is performed by observing the transferred patterns with a scanning electron microscope.

5. A method for measuring aberration of a wafer exposure system during manufacture of a semiconductor device, the method comprising:

providing a photomask including measuring patterns that include apluralility of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process on a wafer to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring a degree of shift of the transferred patterns on the wafer; and

measuring a focus of an exposure system from the degree of the shift of the transferred patterns.

6. The method of claim **5**, wherein the phase difference is 90°.

7. The method of claim **5**, further comprising;

transferring the patterns with variation of aberration of the exposure system and measuring several times the degree of shifts of the transferred patterns; and

obtaining an optimum aberration of the exposure system.

8. The method of claim **7**, wherein the aberration is an astigmatism aberration.

9. The method of claim **5**, wherein measuring the degree of shifts of the transferred pattern is performed by observing the transferred pattern with a scanning electron microscope.

10. A method for measuring focus of a wafer exposure system during manufacture of a semiconductor device, comprising:

providing a photomask including a measuring pattern that includes a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring degrees of shifts of the transferred patterns on the wafer; and

measuring a focus of an exposure system within the degrees of the shifts of the transferred patterns;

wherein the light opaque region pattern is formed in a cross shape, dividing the four quadrants of the light transmitting region patterns, and the degrees of shifts of the transferred pattern are measured from a degree of relative shift of a certain transferred pattern to the other light transmitting region patterns of the quadrant regions.

11. The method of claim **10**, wherein one of the light transmitting region patterns is made of one of the four quadrants of the substrate, and the other light transmitting region patterns are made of grooves with different depths on the other quadrants of the substrate.

12. The method of claim **10**, wherein the degree of shift of the transferred patterns is measured from the transferred patterns, based on the light transmitting region patterns of the quadrant regions in the up/down, left/right or one of the directions during manufacture.

13. A method for measuring focus of a wafer exposure system during manufacture of a semiconductor device, comprising:

providing a photomask including a measuring pattern that includes a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring degrees of shifts of the transferred patterns on the wafer;

measuring a focus of an exposure system within the degrees of the shifts of the transferred patterns; and

disposing a plurality of the measuring patterns on the substrate of the photomask, measuring the degrees of the shifts of the transferred patterns based on the disposed measuring patterns, and obtaining a focus map for all regions on the wafer corresponding to the photomask.

14. A method for measuring aberration of a wafer exposure system during manufacture of a semiconductor device, the method comprising:

providing a photomask including measuring patterns that include a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process on a wafer to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring a degree of shift of the transferred patterns on the wafer; and

measuring a focus of an exposure system from the degree of the shift of the transferred patterns;

wherein the light opaque region is formed in a cross shape dividing the four quadrants of the patterns for light transmitting regions and the degree of shift of the transferred patterns are measured from the degree of shift of the transferred patterns based on the light transmitting region patterns of the quadrant regions.

15. The method of claim 14, wherein one of the light transmitting region patterns is made of one of the four quadrants of the substrate, and

the other light transmitting region patterns are made of grooves with different depths on the other quadrants of the substrate.

16. The method of claim 15, wherein the degree of shift of the transferred patterns are measured from the transferred patterns, based on the light transmitting region patterns of the quadrant regions in the up/down, left/right or one of the directions during manufacture.

17. A method for measuring aberration of a wafer exposure system during manufacture of a semiconductor device, the method comprising:

providing a photomask including measuring patterns that include a plurality of light transmitting region patterns divided by a light opaque region pattern on a substrate, said measuring pattern introducing phase shifts to provide phase differences in light transmitted through the light transmitting region patterns, each light transmitting region pattern having a single depth being different than the depth of each of the other light transmitting region patterns;

performing a photolithography process on a wafer to transfer the light transmitting region patterns and the light opaque region pattern based on the measuring patterns on the wafer;

measuring a degree of shift of the transferred patterns on the wafer;

measuring a focus of an exposure system from the degree of the shift of the transferred patterns; and

disposing a plurality of measuring patterns on the substrate of the photomask, measuring the degree of the shift of the transferred patterns based on the disposed measuring patterns and obtaining an aberration map for all regions on the wafer corresponding to the photomask.

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